TOWARDS THE MODERNIZATION OF THE SCADA SYSTEMS OF THE HELLENIC ELECTRICITY DISTRIBUTION NETWORK OPERATOR – CONSIDERATIONS AND STEPS FORWARD

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ABSTRACT

Currently HEDNO undergoes an upgrade of its Supervisory Control and Data Acquisition (SCADA) systems. As part of this, the Information and Communication Technology (ICT) infrastructure of the organization will undergo a respective change towards data harmonization and smooth interoperation between the heterogeneous ICT systems it consists of. This work presents the current state of the most important of HEDNO ICT systems, in an attempt to point out the diversity and complexity of the ICT infrastructure of such a large organization, and, then, it proposes the implementation of the Enterprise Service Bus (ESB) approach as a means to achieve the desired integration, interoperability and data harmonization between the various ICT systems of HEDNO.

INTRODUCTION

In recent years there is a broader effort by Distribution System Operators (DSO) to integrate their various systems under the pressure of a continuously changing energy environment. Furthermore, major corporations and organizations in recent decades have turned their interest and have gained considerable expertise on the integration of heterogeneous information systems with a view to obtaining more flexibility, better information management and, ultimately, more efficient and effective decision making [1].

The interconnection of various Information and Communication Technology (ICT) systems of a Distribution System Operator is a significant issue for the organization, since it affects different sectors (e.g. network operation, quality of available services, etc.) that have a fundamental and central role in its operation. A first approach of this issue requires the following steps:

- The definition of key business objectives for the interconnection of the systems
- Defining core business processes that will utilize this interface
- The identification of the specific functional features of each system that participates in the interface
- The clear definition of the role of each system based on already defined business processes and functional features.

After clearly defining the operational characteristics (organizational and operational) of the interconnected system, it is necessary to design the integration architecture which is directly connected with both these issues as well as to the technical limitations of the current system and the economic potential the organization.

This paper describes the considerations and planned steps forward to be evaluated and executed by the Hellenic Electricity Distribution Network Operator (HEDNO), toward the modernization of the Supervisory Control And Data Acquisition (SCADA) systems and the underlying information and communication infrastructure.

EXISTING INFRASTRUCTURE

Counting over 60 years of operation in Greece, HEDNO owns today a number of different and non-interconnected Information and Communication Technology (ICT) systems to operate and maintain the electricity distribution network of Greece. These systems are in some cases not interconnected to allow data exchange, while in other cases carry redundant information for the infrastructure and assets owned by the HEDNO. In this section, HEDNO's main information and communication technology systems are presented.

Supervisory Control And Data Acquisition (SCADA)

Two SCADA systems with different functionalities are now operating to maintain the electricity distribution network of Greece. Below there is a brief description about these two systems and their capabilities.

The first SCADA system (No1) is responsible for the supervision and control of the HV/MV substations as well as their Medium Voltage distribution network. This SCADA system will be equipped with advanced Distribution Management System (DMS) functionalities through communication with other systems such as HEDNO's Geographic Information System (GIS) and Automatic Meter Reading system (AMR).

The system consists of two main databases. The first is used for the configuration and operation of the system and contains both static and dynamic information of the current status of the network that is supervised and controlled by the SCADA system. At times, the information of the first database is stored at the second which is used to manage log files (historic data). The history database uses the Relational DataBase Management System (RDBMS) of ORACLE.

The second SCADA system (No2) provides the functionality of topological and geographic representation of the distribution network. In the following tables the main features are presented.

TABLE 1. SCADA (No2) FUNCTIONALITIES

SCADA Functionalities
Remote control of network elements
Remote monitoring of network elements
Logging of measurements
Logging of events

TABLE 2. SCADA (No2) DMS FUNCTIONALITIES

DMS Functionalities
Advanced Alarms management
Network management
Fault management
Outage report
Switching orders
Network simulation
Distribution Feeder Optimization
Load flow analysis
Short Circuit Calculator
Protection Coordination
AVR Application
Load Forecast

Geographic Information System (GIS)

Generally, Geographic Information Systems allow the collection, storage, handling, processing, analysis and visualization of the digital environment of the mapping data. In the Electric Energy Systems domain, the GIS presents all the information related to the electrical network and provides this data to the DMS applications [2], [3].

HEDNO's GIS system is based on a Version Managed Data Store (VMDS) database with external access capabilities. This VMDS database is connected to an external database of ORACLE. This parallel ORACLE database has two main functions: a) Backup, b) an intermediate database for the interconnection of GIS with other HEDNO systems.

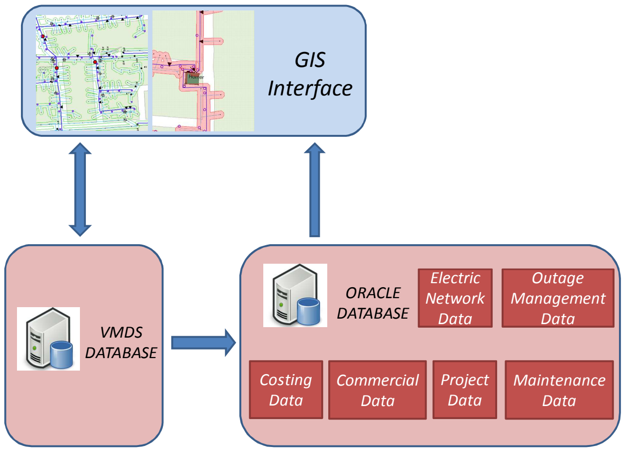

Fig. 1. Available communication routes on HEDNO GIS.

Automatic Meter Reading (AMR)

The Automatic Meter Reading and Meter Data Management (MDM) systems include the entire hardware and software infrastructure that enable the provider to remotely control the smart metering devices and to store and process the metering data for purposes of billing, troubleshooting and analysis. Indispensable part of the AMR system is the smart metering device installed at the consumer's premises. Up to now, smart meters have been installed to all MV customers (since 2007) and to a part of the larger consumers of LV (>85 kVA, approx. 65000). A pilot project is on the way for the installation of 200.000 smart meters to other LV customers using geographical criteria.

The smart metering devices have the capability of measuring maximum, minimum and mean active and reactive power, voltages, currents, power factor and energy (which can be turned to zero at the beginning of the month). The installed smart metering devices communicate with the central system by GSM/GPRS using the protocol IEC 62056, which is based on DLMS/COSEM. However, the future installations will allow for the use of Power Line Communication (PLC).

Customer Management

The current system of customer management and customer service of HEDNO is used, almost exclusively, for billing purposes due to its limited capabilities. However, soon a new system with much wider capabilities and advanced infrastructure (hardware and software) is going to replace the older one. Based on the set requirements, the new system is going to serve for the various needs both for the grid users (consumers, providers etc.) and the HEDNO. As regards HEDNO, the new ICT system, besides the customer service, will provide for the management of the aggregated metering data sent by Telemetry Center and the workforce management. According to the defined specifications, the basic operational requirements for the new system are:

- Integrated ICT system featuring various business processes: The new system features various administrative business processes mainly related to customer management. One of the fundamental features is responsible for the management of the providers and customer (grid users) records and the metering data.
- Interoperability: According to the specifications of the new system special attention is given to the capabilities for interoperability between the subsystems of the system itself and with other information systems of HEDNO that already exist or are to be developed. The new system is planned to be interconnected with ERP system, the GIS, the AMR system and with the system that is responsible for the electricity market clearance of the non-interconnected islands.
- Interconnection with organization portal: The new system is planned to support a web portal that will enable the realization of operations and transactions that are currently performed with a physical presence, a telephone call or in some cases using the official website.

Enterprise Resource Planning (ERP-SAP)

The ERP-SAP project in HEDNO started its operation in 1.1.2014 and it unified many of the basic administration processes of the company which operate through the system in a single, integrated platform.

Thanks to the interconnection of the various subsystems of ERP-SAP, the diffusion of information to all stakeholders from a single registration point is possible. This makes operational information easily accessible, allowing a better picture of the company's operations and making safer strategic choices by the qualified personnel with regard to the operation, organization and management of HEDNO.

The basic ERP-SAP subsystems used in HEDNO are:

- Financial management
- Supply chain
- Project management
- Sales Management
- Human resources management

The ERP-SAP system is interfaced with some already existing, computer applications of the company.

PROPOSED INTERFACE BETWEEN THE VARIOUS SYSTEMS.

The interconnection of organization information systems is a complex issue both at the design and the implementation level, without ready off-the-shelf solutions. Actually, the solutions for the system interconnection are determined by business objectives for the interoperability, various technical constraints, economic and other, structural to the organization, factors.

Big companies and organizations, such as HEDNO, use large and complex information systems to meet their various needs. These systems are strategic investments and large-scale projects which are purchased and utilized in the course of business operation (which might span decades) and in most cases from different manufacturers. With the passage of time and with the occurrence of new (or with the change of already existing) business operations new interfaces between the information systems might be required. When this is not implemented in a structured way, it results in the creation of the so-called «spaghetti» networks, i.e. networks based on point-to-point communication between systems such as the one shown in the following figure [4].

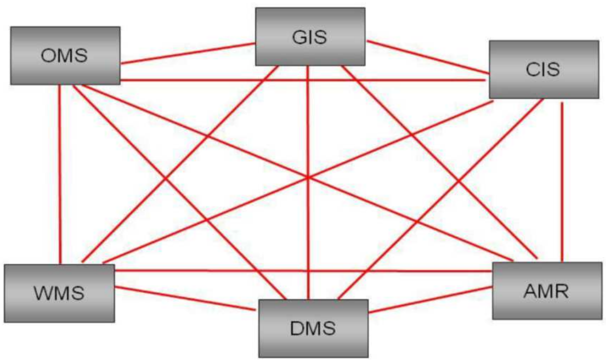

Fig. 2. Network based on point to point communication

Such a structure of the information systems interconnection, while at the implementation level can be considered perhaps simpler when the need for interconnection arises (it is the interface only between two systems), in the long run results to the following issues:

- Close dependence (tight coupling) between the systems
- Minimum operational flexibility
- The information is produced and processed more than once and stored in different places

To address these issues and to achieve integration and

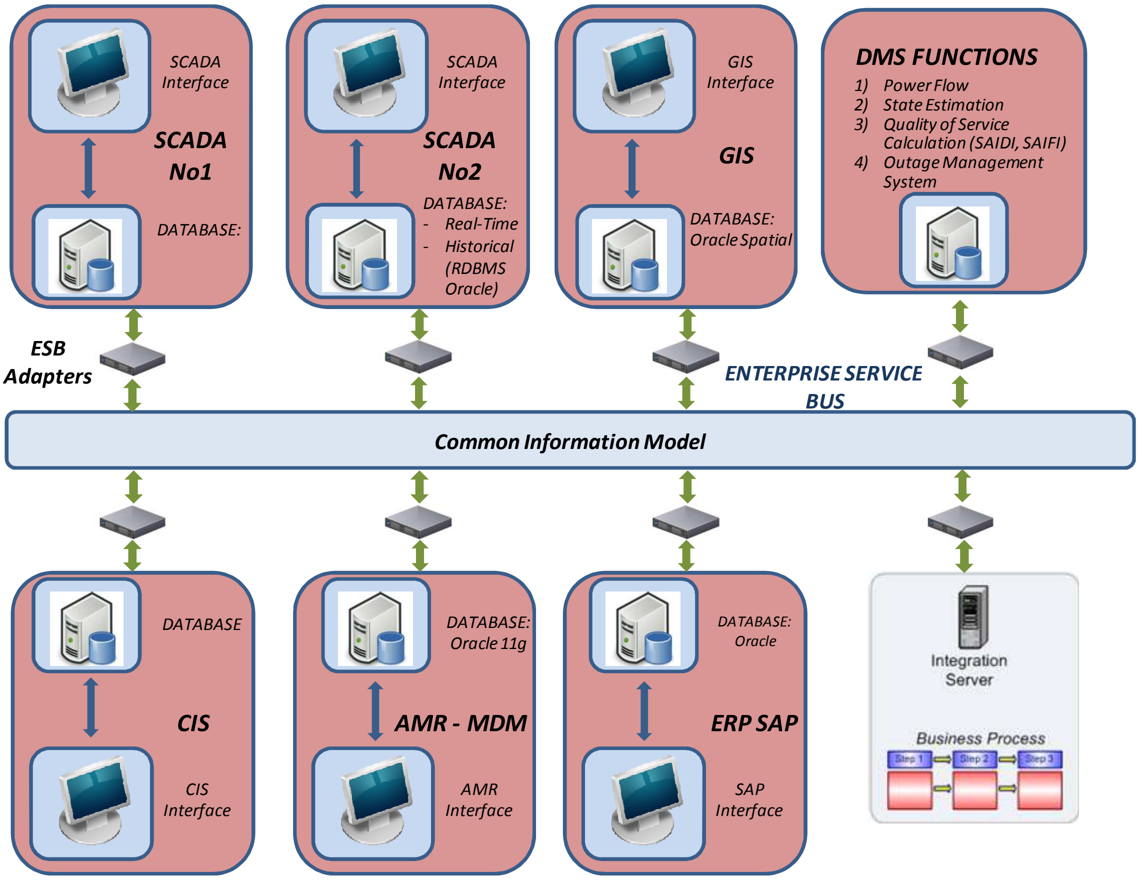

Fig. 3. Integration of HEDNO systems using an Enterprise Service Bus

interoperability of multiple information systems, an Enterprise Service Bus (ESB) will be implemented providing the necessary data harmonization between the various systems [4].

ESB is a middleware, i.e. software (with the required hardware) which provides "intermediary" services (broker) between different operating systems. Its main role is to enable the integration and interoperability between applications that are implemented in heterogeneous systems, software platforms and communication protocols. In this way, the overall system (system of systems) allows for a uniform and consistent access to the information available in the entire organization.

Generally, an ESB system has the following features:

- Transport and conversion of the available information on the full range of the company.
- Intelligent routing of data according to the needs of each application.
- Monitoring and logging of events and messages between services and applications.
- Registration of all the available services (service registry) and execution sequence management based on defined business processes.
- Safety in the transport and management of messages and data (security).

ESB allows each system to be independent of the implementation and the architecture of each of the individual. This is because the information transfer and the exchange of messages is done using a common format (information model) and at the input of each system there is an appropriate interface that makes the conversion into a format understandable by the local system. Because of this characteristic the ESB enables the replacement of any new system without requiring reconfiguration of the rest of subsystems [4].

The nature of the ESB is service-oriented and, in practice, it implements the principles of Service Oriented Architecture (SOA). This architecture uses services with strictly defined interfaces which they, eventually, implement the various business processes utilizing its available resources (i.e. the integrated systems). Each service depends at a very small extent on the rest of the services (loosely coupled).

By using SOA architecture and utilizing ESB as the "backbone" that unifies the systems, various operational functions (such as DMS) and company's business processes can be implemented using the appropriate interfaces. So, instead of the communication to be made directly between subsystems, the applications publish/subscribe their various messages through ESB. ESB is, then, responsible to launch and make the mapping between the data models of the individual systems (different protocols). The sender does not need to know the exact location of the receiver or the structure of the information used and also data from a sender can be received by several receivers. Thereby sending data and messages becomes effective.

The implementation of the integration of HEDNO systems using an Enterprise Service Bus is shown in Fig. 3. Each system has its own interface to the ESB (referred to as ESB adapter).

In such an implementation, the sub-systems are treated as distributed resources that provide specific services to implement a business process of the organization. Each of these systems can be a service client or service provider. For the control of the service requests, the routing of messages and data and the coordination of the sequence of processes, responsible is the ESB, which is practically implemented by the integration server. So, for example, when a subsystem needs specific data to implement a function it operates as service client and is addressed to ESB, who has a service repository with all available services that can offer the subsystems. The ESB then requests the service performed by the appropriate system (service provider) and the results are returned and passed to the service client. A similar process takes place for the exchange of messages.

EXAMPLE OF INTERCONNECTION BASED ON THE ESB APPROACH

In this section one example of system interconnection based on the ESB approach is presented. The load flow – state estimation analysis is presented based on the ESB approach. The following figure presents the sequence diagram of the exchanged information to perform this application

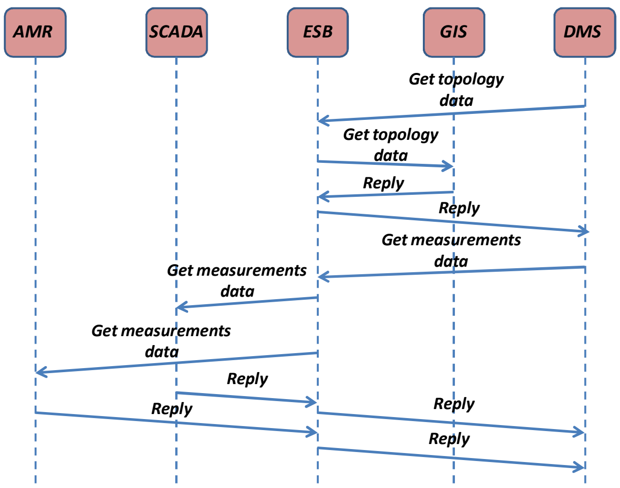

Fig. 4. Load flow – state estimation sequence diagram based on the ESB approach

CONCLUSIONS

In this paper, initially, the most important systems of the ICT infrastructure of HEDNO are listed and presented. These systems are vital for the organization and for the operation and maintenance of the electricity distribution network of Greece. Even more, the information that is produced, stored and handled by the entire ICT infrastructure is a precious asset of HEDNO. However, these systems form a diverse and heterogeneous system environment where the asset data is most likely scattered and redundant, a fact which significantly reduces the flexibility and effectiveness of the organization. As a result of that, the necessity for system integration and data harmonization occurs. This work presents a step towards that direction by proposing the implementation of the Enterprise Service Bus (ESB) approach at the ICT infrastructure of HEDNO. In this way, the overall system (system of systems) allows for a uniform and consistent access to the information available in the entire organization. Finally, an example of system cooperation (which implement DMS application) based on the ESB approach is given.

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